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91. RESPONDING TO A TERRORIST INITIATED TOXIC CHEMICAL RELEASE: PROTECTING HIGH VALUE FACILITIES AND VERY VULNERABLE POPULATIONS

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ABSTRACT

The release of a toxic chemical agent in a densely populated urban area, whether the direct result of a deliberate terrorist event or as an accident, poses a wide variety of serious challenges for crisis management authorities. The immediate concern is collecting information in a timely fashion so that first responders can take appropriate action to protect people and certain high value facilities such as emergency control centers, fire and police stations, military or national guard bases, and utility control centers from the toxic chemical agent. Timely and accurate information is critical to crisis managers who must decide whether to evacuate highly vulnerable populations, from locations such as hospitals, schools, retirement centers, and detention facilities. Specifically, first responders must know the direction, duration, and probable effects of toxic plumes in order to protect these populations.

This paper will discuss a solution offered by the Risk Management Planning (RMP) Chemical Plume Detection System. Originally developed by Dupont®, the RMP system is the result of a combined effort among industry scientists, academicians at the University of Wisconsin and the University of Mississippi, and is supported by remote satellite imagery provided by the National Aeronautics and Space Administration (NASA).

The RMP system is the world's only chemical plume detection and mapping system that uses real-time, on-site meteorological data and combines it with mathematical algorithms which describes and anticipates the ways that chemical gases "move" through the atmosphere. In addition, the RMP system is enhanced by the Cityscape® modeling feature that uses NASA satellite imagery to literally paint a picture of how gases move within an urban environment. The RMP system currently is being upgraded to add biological and radiological sensors to the meteorological towers and this new data will be imported into the overall model providing additional capabilities.

This paper will review how the RMP model is presently being employed and field tested by authorities in New Orleans, Louisiana.

BACKGROUND

Recent experience indicates that first responders and public health officials are ill-equipped to deal with the results of a terrorist inspired chemical gas attack. Experience gained from the 1995 Tokyo subway attack demonstrated that civil authorities had no readily available technology to detect the identity of the toxic plume in the subway or to predict how others in the vicinity could be impacted. Fortunately, the attack within the bowels of the Tokyo subway system, kept the chemical gas from widely dispersing throughout the city. If the event had occurred above ground, local wind and weather conditions would have determined the direction of the plume and, consequently, the number of people at risk to death or injury.

The RMP system has been designed to provide command and control information to government authorities and crisis managers in response to such an event. The RMP system employs both mobile and fixed meteorological (MET) towers. The self-aligning unit

continuously transmits real-time data to an operations center. The data is logged every second and five minute average reports are generated to create plume maps of the affected area.

This data includes wind speed and direction, temperature, barometric pressure, solar radiation and relative humidity. Since the data is real time and is continuously updated, crisis managers can remain flexible in deploying response assets in an environment where the weather is rapidly changing.

In theory, such meteorological data, collected in a flat terrain and open environment should provide a good predictive model of where and how fast the chemical plume will travel. However, in areas of complex terrain or densely built up urban areas, it becomes crucial to account for topographical features in modeling the dispersion and transport of a chemical release.

CREATING A VALID URBAN MODEL

How can a valid model of an urban area be created using this collection of meteorological data ? What elements must be incorporated into the design to insure that we are really modeling what we think we are ?

RPM first tested this system during a US Government anti-terrorism exercise carried out in New York City. Operation ICE simulated a sarin gas release in Manhattan and mapped the flow of the simulant in a densely populated, highly built up urban environment. The results of this test demonstrated that a plume can move up and down streets, turn corners, and generally behave in a fashion that might appear counterintuitive. That is, just because there is a brisk wind blowing out of the north, the plume may not necessarily move in a strict southerly direction.

In addition, the risk to residents of a particular building is a function of the air handling system. Air vents and subway ventilation pipes can draw the plume into a specific area. Facilities with centrally controlled air handling systems can regulate the amount of outside air brought into the building. Reducing the air intake can mitigate the amount of toxin introduced into a facility. In addition, tall buildings create micro-wind fields that create swirling patterns and large, massive buildings like a sports arena can generate changes in the ambient barometric pressure causing the plume to move towards an area of a lesser pressure. All of these structures affect how a chemical plume will behave.

New Orleans is an important test bed for the RMP system. First, most of the city of New Orleans is actually located below sea level. This is a different situation than, say Dubrovnik, because we test the behavior of a chemical plume that flows to lowest point in the area. In other words, the plume will "hug" the streets of the city as it moves to the coastline. Second, a large portion of all chemicals that are shipped in the US every year pass through New Orleans so the possibility of accident is quite high. Third, in cooperation with NASA, we have been able to create an accurate model of the city complete with all existing building's scaled to real size. Taken together, we have been able to identify specific buildings, housing vulnerable populations, which would be under extreme risk if a chemical gas incident were to occur in the New Orleans area.

HOW THE RMP SYSTEM WORKS

The RMP system offers crisis managers two options. First, it can be used as an area planning and crisis management tool. With strategically placed MET towers in an urban environment, the RMP system can provide real time data on the behavior of a plume in the city streets. Second, the RMP system can incorporate data from particular facilities, e.g., hospitals or schools, and be used to make decisions whether or not to evacuate. The analysis of a building permits authorities to identify spots where gas could leak into a building or where

it would be drawn in by the ventilation system. This information is included in a comprehensive emergency action-planning document. Additionally, three separate models are included in the overall analysis and this information is also added to the model.

INFILTRATION/EXFILTRATION MODEL

The key issue that faces emergency authorities when a chemical release occurs is what to do about specific populations in buildings that may be at risk from a toxic chemical plume. Should the building be sealed or evacuated? How much time would be needed to evacuate the site and where would the occupants be taken? How long before it is safe to return to the affected building? If the building is sealed, when can it be re-opened?

To answer these questions, the infiltration portion of the RMP model calculates the average indoor concentration and dosage within the building. This is carried out when there is an external release of an agent which will impact a particular building or a vulnerable population in a specific area. The calculations are based on the construction of the building and its primary air exchange rate coupled with an analysis of the outdoor chemical concentration levels and local meteorological conditions. This provides for a determination of the time that the indoor and outdoor concentrations reach a safe level so that the building can be reopened.

The system is also relevant in the event that a toxic chemical release occurs within a particular building, such as a major high rise housing government offices. The rate at which a chemical can subsequently be released into an outdoor environment will be calculated using an analysis of the building's vents and air flow exchanges and added to local meteorological conditions. This data will be imported into the overall RMP model so that the plume can be tracked after it is released from that structure. This portion of the model will be able to identify when it is safe to return into a particular building.

OTHER INFORMATION PROVIDED BY THE RMP MODEL

Additional information is required by emergency and response personnel. The RMP system provides plume graphics, downwind impact reports, toxicological reports, first aid reporting, population impacts and human response reports. The last two are extremely important in protecting vulnerable populations or high value buildings.

The Human Response Model predicts the toxic response of an individual, within an average population, by taking into account the specific chemical toxicity of the particular agent(s) in the release. This is calculated to determine injury and mortality impacts in a given area.

The Population Impact Model estimates the number of people who may be impacted from the release by taking a number of variables into account: the actual population distribution pattern for a given area, evacuation times, sheltering options, and the aforementioned building infiltration rates. The model then employs an infiltration algorithm to calculate impact reports identifying toxic loads, lethal exposure potentials, indoor dosages and concentration profiles as well as total numbers of individuals impacted by the release.

Taken together, these three models provide a complete picture of what impact a chemical release will have on a specific area, building or vulnerable population. This is critical to developing alternative methods to protecting life and property in areas that may be vulnerable to certain types of releases, i.e., urban business areas that are adjacent to a harbor facility where large quantities of chemicals may be transshipped. At the same time, the data from these models can be used to develop better coordination among emergency response and government agencies and allow them to model different scenarios for specific buildings which house sensitive facilities or are home to vulnerable populations.

MULTICOMPONENT RELEASES

It is often assumed that a toxic release would only involve a single chemical agent during an incident. However, a multicomponent release forces the model to simultaneously carry out a number of calculations since dispersion rates of each component and their toxicity levels must be calculated. At the same time, pool evaporation rates for each component must be derived and inputted into the model.

At the present time, the RMP model has analyzed multicomponent releases involving aqueous solutions of hydrochloric acid, ammonia, formaldehyde, fuming mixtures of chlorosulfonic acid, fluorosulfonic acids and oleums. An event, such as a truck bomb or a train derailment, can cause the release of those chemicals in addition to those released initially. An explosion in or near a manufacturing facility that uses toxic chemicals in its production processes could trigger the release of those chemicals. Thus, it would not be prudent to assume that a gas plume from a toxic release would only contain a single agent. Moreover, because each chemical behaves in a different fashion, an accurate prediction of how the movement of a plume will impact a particular building must take the multicomponent issue into account. The RMP model incorporates these calculations into the overall analytical product.

THE NEW ORLEANS CASE STUDY

The RMP model will be tested in New Orleans to verify the components of the model. Vulnerable buildings have been identified and analyzed to develop an emergency response plan so that in the event of an incident, authorities located within the building have specific steps to take. For example, at Charity Hospital, an evacuation plan would move non-ambulatory patients into a loading dock area for transport on large, delivery type vehicles is in place. At the same time, procedures for shutting down ventilation systems and sealing the building are in place. Similar plans have been developed for a number of schools and emergency related government buildings located throughout downtown New Orleans. The detention center provides a difficult situation since it is located adjacent to the New Orleans waterfront and is in the lowest spot in the city. In the event of a chemical release, the plume would tend to flow towards a building holding thousands of prisoners in hundreds of locked cells. It would be impossible to evacuate this building in a short period of time.

Will these actions dictated by the RMP system completely safeguard the entire population within these buildings? Probably not. However, after adopting the RMP system, the odds for safe evacuations and minimal injuries and deaths will greatly increase. The very fact that we have walked the planners and responders through a detailed plan that can be used in the event of a chemical plume incident in and of itself dramatically improves the odds that the event can be managed in a more responsible fashion.

CONCLUSIONS

The RMP system is designed to save lives and minimize property damage in the event of a toxic chemical release, either one that is accidental or the deliberate results of a terrorist action. The system has been field tested and it has been proven to enhance cooperation and coordination among emergency response agencies. The installation of the system makes a powerful statement about a government's willingness to take a proactive stance in ensuring the safety of the community. In that regards, it is an important tool in the psychological battle between the civilized world and those extremists who wish to employ a weapon of mass destruction to advance their political objectives. Moreover, the deployment of the RMP system can be used as a strong deterrent and it will put terrorists on notice that their attempts

at disrupting an urban area with a chemical attack will be met with a corresponding action to minimize these actions.

Use of the RMP system will reduce training costs, reporting burdens, and planning time for emergency response agencies while serving to fully integrate real-time solutions into a comprehensive response plan.

KEY WORDS

Plume analysis, population impacts, vulnerability analysis, risk analysis